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WATER RESOURCES STUDY. ROWLESBURG RESERVOIR CHEAT RIVER BASIN, WEST VIRGINIA AND PENNSYLVANIA

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
CHARLOTTESVILLE, VIRGINIA

PREPARED FOR
ROBERT A. TAFT SANITARY ENGINEERING CENTER
CINCINNATI, OHIO

JANUARY 1964

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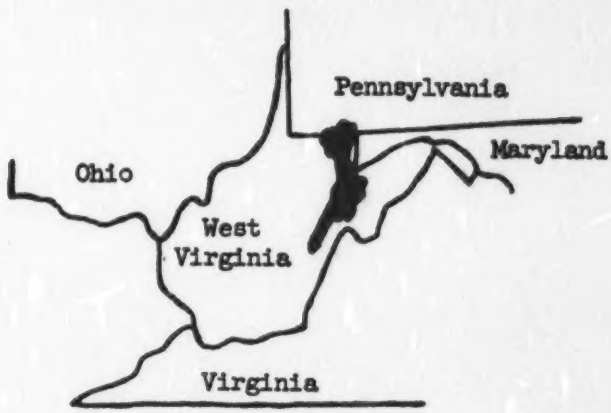
WATER RESOURCES STUDY
ROWLESBURG RESERVOIR
CHEAT RIVER BASIN
WEST VIRGINIA AND PENNSYLVANIA

Study of Potential Needs for Municipal and Industrial Water Supply and Water Quality Control



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Public Health Service, Region III
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WATER RESOURCES STUDY
ROWLESBURG RESERVOIR
CHEAT RIVER BASIN
WEST VIRGINIA AND PENNSYLVANIA

A Study of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes

By
U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Charlottesville, Virginia
and
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

Prepared in cooperation with the
Department of the Army
U. S. Army Engineer District - Pittsburgh, Pennsylvania

January 1964

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I. INTRODUCTION

Authority

This study was initiated at the request of the District Engineer, Corps of Engineers, Pittsburgh, Pennsylvania, by letter dated December 1, 1960. The letter requested the cooperation of the U. S. Public Health Service in determining the need for streamflow regulation for water quality control and the value of benefits which could be provided by a reservoir on the Cheat River at Rowlesburg, West Virginia. The Corps of Engineers is reviewing its previous report of the Cheat River prepared in 1944 (House Document No. 645, 78th Congress, 2nd Session).

Authority to conduct this study is provided in the Federal Water Pollution Control Act (Public Law 84-660, as amended by Public Law 87-88) and in a Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, implementing the Water Supply Act of 1958 (Title III of Public Law 85-500, as amended by Public Law 87-88).

Purpose and Scope

The purpose of this report is to determine municipal and industrial water supply and quality control needs which could be served by a proposed multiple-purpose reservoir on the Cheat River near Rowlesburg, West Virginia, and to determine the value of storage provided in the reservoir to satisfy the needs. The study area covers the Cheat River Basin and the area along

the Monongahela River between the Cheat River confluence and the Ohio River. Project needs and benefits have been evaluated on a 50-year basis.

Acknowledgments

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U. S. Army Engineer District, Pittsburgh, Pennsylvania

U. S. Geological Survey

West Virginia Department of Natural Resources

Pennsylvania State Health Department

Allegheny County Planning Commission

Charleroi Water Authority

South Pittsburgh Water Company

II. SUMMARY AND CONCLUSIONS

Summary

1. The proposed multiple-purpose Rowlesburg Reservoir will be located on the main stem of the Cheat River near the town of Rowlesburg, West Virginia. At full pool the reservoir will extend about 34 miles upstream to Parsons, West Virginia.

2. The Cheat River is a swift mountain stream draining 1,425 square miles in northern West Virginia, western Maryland, and southern Pennsylvania. It is tributary to the Monongahela River which flows through western Pennsylvania in a northerly direction to subsequently form the Ohio River at the confluence with the Allegheny River (see Figure III in back of report).

3. The average annual discharge of the Cheat River at Rowlesburg based on 37 years of record (1923-1960) is 2,236 cubic feet per second. The maximum flow was 66,300 cfs, occurring on October 16, 1954; the minimum flow was 10 cfs, occurring on October 15, 1930.

4. The Cheat River Basin is a sparsely settled, mountainous area, having only a few small industries other than those involved in the mining and production of coal. The population of the Cheat River drainage area is estimated to be approximately 40,000 people, which includes an urban population of about 15,000. The economic study area, which is based on the counties most nearly coinciding with the drainage basin, includes area outside the basin and has a population of 61,300.

5. The present municipal water use by the 10 principal communities in the Cheat River Basin is about 2 mgd.

6. The quality of the Cheat River is generally good, except for adverse effects resulting from acid mine drainage. Acid conditions prevail on most of the Cheat River tributaries that drain coal mining areas. The major acid problem in the main stem results from intermittent acid slugs from the tributaries.

7. The minimum daily flow of the Monongahela River in the Pittsburgh area (Braddock gage) available in 49 years out of 50, the flow considered dependable for water supply purposes, is 1,350 cfs (880 mgd). The minimum 7-day mean flow available in 9 years out of 10, the flow considered dependable for quality control purposes, is 1,820 cfs.

8. The area along the Monongahela River below the Cheat River confluence is highly industrialized. The greatest use of the Monongahela River for municipal and industrial water supply and for waste disposal occurs in the vicinity of Pittsburgh. Water navigation and the close proximity to vast coal reserves have been major factors in this development.

9. The 1960 population of the Monongahela River economic study area was 2,675,531. This area includes the Pittsburgh Standard Metropolitan Statistical Area.

10. Municipal water use along the main stem of the Monongahela River between the Cheat River confluence and the Ohio River is about 81 million gallons per day and serves an estimated 600,000 persons (135 gpcd). Industrial water use in this reach is slightly in excess of 1,700 mgd plus an additional 4,350 mgd used for cooling purposes. The Monongahela River is also used to convey acid mine drainage, sewage, and industrial wastes.

Conclusions

1. The population of the study area is expected to increase at a rate less than the national average. The population of the Cheat River Basin economic study area is expected to increase from 61,300 as of 1960 to about 90,000 by 2010. The population of the Monongahela River economic study area is estimated to increase from 2,675,531 to 4,100,000 by 2010.

2. Municipal water use in the Cheat River Basin is expected to increase to about 4 mgd by 2010. Only one of the supplies is taken directly from the Cheat River and the supply is adequate for anticipated needs.

3. Based on projections of industrial employment and supporting populations, municipal and industrial water use in the Monongahela River below the Cheat River confluence is expected to increase to about 2,800 mgd (excluding cooling water use) by year 2010. No single projected municipal or industrial water supply requirement is expected to exceed the dependable streamflow at Pittsburgh.

4. As a result of the fact that the Monongahela River is entirely canalized, water is available to meet present and future municipal and industrial water supply needs, except as reuse of the stream may be prevented by excessive quality degradation. No storage for municipal and industrial purposes is needed in the proposed project to meet anticipated needs over the next 50 years.

5. The reach of the Monongahela River in the vicinity of Pittsburgh is expected to continue to receive the greatest waste load of the entire

stream system. Even with provision of adequate treatment of municipal wastes and treatment or equivalent control of industrial wastes, summer flows of as high as 4,000 cfs will be needed to assimilate anticipated organic waste loads by 2010. This exceeds the present flow of the Monongahela River considered dependable for quality control purposes at Pittsburgh. If streamflow is maintained by regulating Cheat River at Rowlesburg to meet quality control needs in the Pittsburgh area, sufficient flows will be available for quality control purposes in upstream reaches between Pittsburgh and Rowlesburg Reservoir.

6. Regulation of Cheat River discharges could provide increased assured flows in the Monongahela and Ohio Rivers, reduce hardness and acidity concentrations, and result in other water quality improvements.

7. The benefits estimated in this study are predicated on the release of a relatively uniform quality of water from Rowlesburg Reservoir. If the quality of the discharge is reduced as a result of thermal stratification, density underflow, or other conditions, then benefits will be reduced. Multiple-level outlets, together with information on water quality at several depths, will make possible the flexibility in management necessary to maintain acceptable dissolved oxygen, uniform temperatures, and minimum acidity concentrations in reservoir discharges. Provision should therefore be made in the design of Rowlesburg Dam for multiple-level outlets and access for water quality monitoring equipment.

8. Storage to yield an annual draft of 471,500 acre-feet will be needed by 2010 to assure streamflows required to assimilate organic waste loads reaching the Cheat and Monongahela Rivers after provision of adequate treatment

of municipal and industrial wastes. Provision of storage in Rowlesburg Reservoir to maintain these flows will result in benefits having an estimated average annual value of $2,648,000.

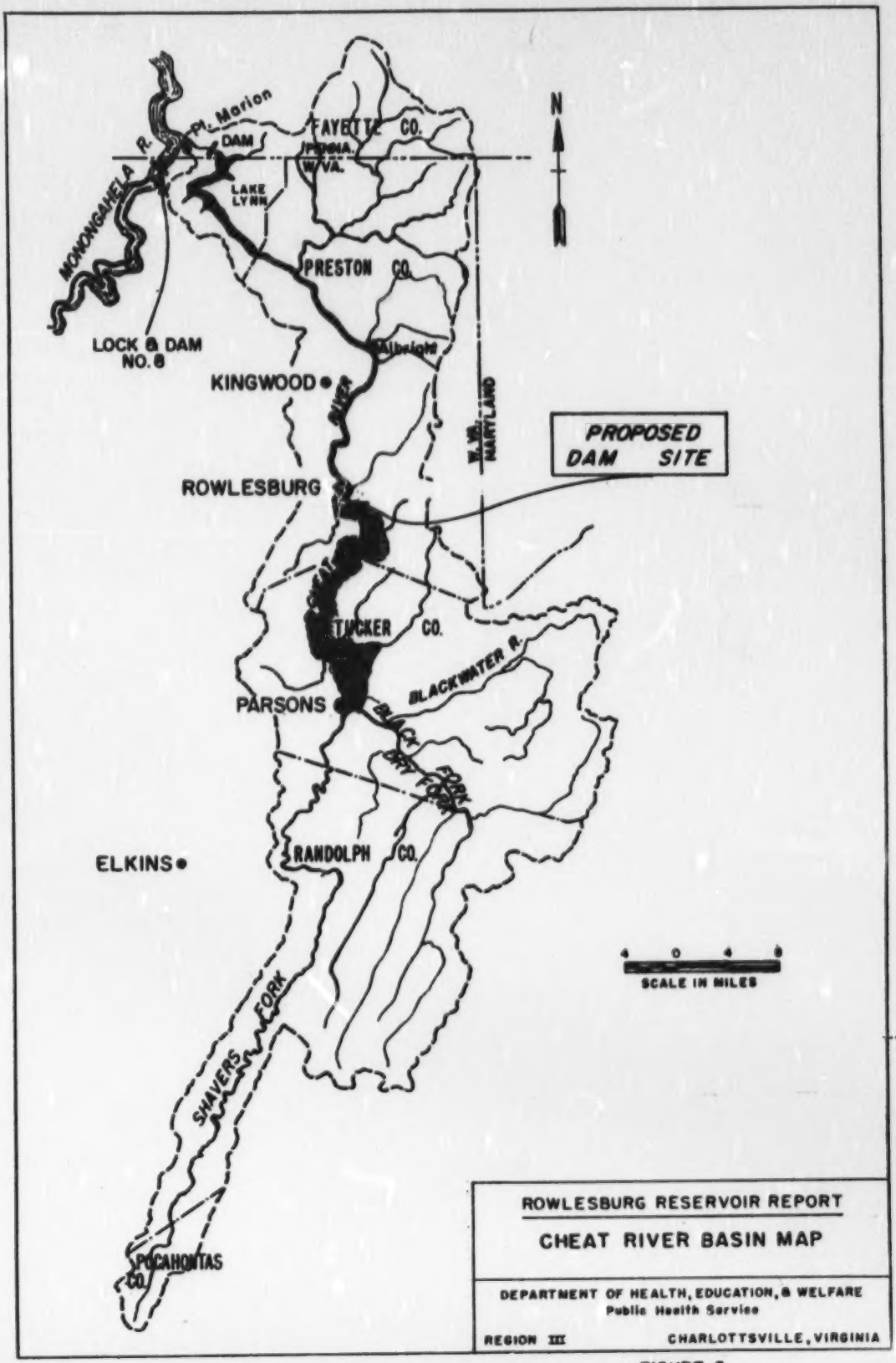
9. While the benefits discussed apply primarily to the Cheat and Monongahela Rivers, widespread benefits to water quality will also be realized along the entire length of the Ohio River.

10. These storage needs and benefits are subject to review and revision based on comprehensive studies of the Ohio River Basin currently under way but may be used for project evaluation at this time.

III. DESCRIPTION OF PROJECT

As presently proposed, Rowlesburg Reservoir will be located on the Cheat River in the vicinity of the town of Rowlesburg, West Virginia, about 44 miles upstream from the mouth of the Cheat River (see Figure I). The reservoir will control runoff from 936 square miles of drainage area in northern West Virginia (see Figure I). Some physical data on the proposed reservoir are presented below:

	Elevation ft.	Surface Area acres	Storage acre-feet
Flood Control	1,632	9,140	
Summer			250,800
Winter			299,600
Proposed Water Quality and/or Power			
Summer	1,601	7,175	571,500
Winter	1,594	6,780	522,700
Minimum Pool	1,420	550	9,400
Streambed	1,375		
		Total Storage	831,700



ROWLESBURG RESERVOIR REPORT

CHEAT RIVER BASIN MAP

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION III CHARLOTTSVILLE, VIRGINIA

FIGURE I

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

Cheat River Basin has an area of 1,425 square miles and is located in the Allegheny Mountain region of northeastern West Virginia, western Maryland, and southern Pennsylvania, as shown in Figure III in the back of the report. It lies principally in the counties of Preston, Tucker, Randolph, Monongahela, and Pocahontas in the State of West Virginia and extends into Fayette County, Pennsylvania, and Garrett County, Maryland.

That part of the Monongahela River Basin considered in this study extends from the Ohio River at Pittsburgh upstream to the Cheat River confluence at Point Marion, Pennsylvania. This portion of the Monongahela River flows through five principal counties in Pennsylvania; namely, Allegheny, Washington, Westmoreland, Green, and Fayette.

Description

The Cheat River is a fast-flowing mountain stream with many rapids and extensive exposed rock formations. There is a difference in elevation of approximately 4,000 feet between the highest ridges in the southern part of the basin and the confluence of the Cheat with the Monongahela River at Point Marion. The Monongahela River flows in a northerly direction about 90 miles to join the Allegheny River at Pittsburgh, forming the Ohio River.

The Cheat River Basin is a sparsely populated, mountainous, coal mining region, containing numerous scenic and forest areas that are extensively used for recreation. Monongahela National Forest, Coopers Rock State Park,

and Lake Lynn, all offer excellent recreational facilities within the basin.

In contrast, the Monongahela River passes through an area of heavy industrialization, the concentration of which progressively increases toward Pittsburgh. These industries are involved chiefly in the manufacture of iron and steel. The Monongahela River is extensively used for navigation and is canalized to and above the confluence of the Cheat River for that purpose.

Hydrology

The average discharge of the Cheat River at the Rowlesburg USGS gaging station for 37 years (1923-1961) was 2,236 cfs for 972 square miles of drainage area. At this station a maximum known discharge of 66,300 cfs occurred on October 16, 1954; a minimum flow of 10 cfs occurred on October 15, 1930. The minimum 7-day mean flow at the Rowlesburg gaging station available in 9 years out of 10 is 20 cfs. Over the 10-year period from 1950 to 1959, the discharge was less than 50 cfs an average of 10 days per year and less than 300 cfs an average of 58 days per year.

The average discharge of the Monongahela River at Braddock, Pennsylvania, (about 11 miles upstream from the Allegheny confluence) is 12,440 cfs, based on 22 years of record. At this location (draining 7,337 square miles) the maximum discharge was 201,000 cfs on June 5, 1941, and the minimum daily discharge was 703 cfs in September of 1946. The average daily flow available

in 49 years out of 50 is 1,350 cfs. The minimum 7-day mean flow available in 9 years out of 10 is 1,820 cfs. Analysis of daily flows shows that minimum daily flow at Braddock may be expected to be in excess of 1,820 cfs, 90 percent of the time and in excess of 1,350 cfs, 98 percent of the time.

Two reservoirs are operated in the Monongahela River Basin to produce hydroelectric peaking power. These are Lake Lynn Reservoir on the Cheat River and Deep Creek Reservoir on Deep Creek, a tributary to the Youghiogheny River in Maryland. In addition, two reservoirs are operated for flow regulation purposes. These are Tygart Reservoir on the Tygart River and the Youghiogheny Reservoir on the Youghiogheny River (see Table 1). There are also 12 navigation locks and dams on the main stem of the Monongahela River.

Water Quality

Extensive water quality data have been collected and show considerable change in water quality over the years. Data from water treatment plants on the Monongahela River and from the Corps of Engineers on the Cheat River were used as the basis for determining probable improvements in water quality by flow regulation from Rowlesburg Reservoir. Water quality of the Cheat River is generally good having a pH of about 6.0, a mean mineral acid concentration of 10 mg/l, and a total alkalinity concentration of 9 mg/l.

In the Monongahela River at Charleroi, Pennsylvania, pH values were generally lower. Total acidity concentrations ranged from 30 mg/l

Table 1

Reservoirs in the Monongahela River Basin

State Name of Reservoir* Name of Stream	Drainage Area sq.mi.	Dead Storage acre-ft.	Total Storage acre-ft.	Usable Storage acre-ft.	Surface Area acres	Storage Ratio years	Date Completed	Use Owner or Operator
Maryland Deep Creek Deep Creek	68.5	13,085	106,060	93,000	4,500	1.2	1925	Power Pennsylvania Elec. Co.
Pennsylvania Youghiogheny River Youghiogheny River	434	5,230	254,000	248,770	3,566	0.4	1943	Flood Control, Recreation, Industrial Corps of Engineers
West Virginia Lake Lynn Cheat River	1,413	45,000	72,300	19,700	1,730	0.05	1926	Power West Penn Power Co.
West Virginia Tygart Tygart River	1,184	11,200	289,600	278,400	3,440	0.2	1938	Flood Control, Navigation, Power Corps of Engineers

*Only those reservoirs are listed that have a usable capacity of 5,000 acre-feet or more.

at flows of about 2,000 cfs to 60 mg/l at flows around 500 cfs. Table 2 contains the average results from a 2-week water quality survey that was conducted in August of 1963 by the Public Health Service in the Monongahela River Basin. It can be concluded in a general way that throughout the survey period the surface water quality in the Monongahela and Cheat Rivers above Charleroi, Pennsylvania, was generally good except for the presence of acid. At Station M-414 (at Charleroi, Pennsylvania) the average acidity concentration of 10 samples was 24 mg/l, the maximum was 39 mg/l, and the minimum was 14 mg/l. At this same station the hardness ranged from 108 to 284 mg/l, averaging 173 mg/l. This is much greater than the average hardness of 28 mg/l found at Rowlesburg on the Cheat River.

Table 2

Surface Water Quality*
Monongahela and Cheat Rivers
1963

River Mile	Flow cfs	Hot Phenolphthalein Acidity as $CaCO_3$, mg/l	Alkalinity as $CaCO_3$ mg/l	Hardness as $CaCO_3$ mg/l	pH	D.O. mg/l	Temp. °C.	Specific Conductance Micromhos per cm
M-41.4	2,402	24		173	4.0	8.9	24	487
M-85.0	2,441	22		106	3.8	716	23	367
M-89.4	Cheat River Confluence							
M-90.7	1,940	24		133	3.9	8.2	24	391
M-98.0	1,710	23		143	4.1	8.2	23	395
C-3.0	1,330	10	1	45	4.5	7.9	24	134
C-9.3	1,300	5	3	40	5.1	7.1	24	106
C-27.7	960	4	5	36	6.1	8.1	26	91
C-40.9	913	2	10	28	6.7	8.4	21	67

*Average of results from 2-week survey in August of 1963 by the PHS as reported in "Monongahela River Basin Study - 1963."

M = Monongahela River above Pittsburgh, Pennsylvania.

C = Cheat River above Point Marion, West Virginia.

V. THE ECONOMY

Present

Study Area

An appraisal was made of the economy of the Cheat River Basin and also of parts of the Monongahela Basin which may be affected by the proposed Rowlesburg Reservoir facility. The three counties of Preston, Tucker, and Randolph in West Virginia, which most nearly cover the basin, were considered representative of economic conditions of the basin. The Monongahela River Basin is included to show the magnitude of industrial development in the area immediately downstream from the Cheat River confluence and to appraise the effects of the proposed reservoir development on water supply and water quality control needs in that area. The Monongahela economic study area includes the six Pennsylvania counties of Allegheny, Beaver, Washington, Westmoreland, Green, and Fayette, which includes the Pittsburgh, Pennsylvania, Standard Metropolitan Statistical Area.

As a basis for evaluating prospects for future growth, the area's competitive advantage in attracting new or expanding existing industry to supply the increasing regional and national demand for goods and services were investigated. A broad approximation of future growth potential was derived and expressed in terms of representative economic indicators (see Tables 3 and 4) by comparing past trends between the study area, the State, and the nation.

Table 3

Rowlesburg Reservoir Report
Industrial Employment, Cheat River Study Area
1940, 1950, 1960

Employment Category	1940			1950			1960		
	Number	Percent	L.Q.[1]	Number	Percent	L.Q.	Number	Percent	L.Q.
Agriculture[2]	4,363	18.7	1.2	3,510	16.1	1.4	1,576	8.6	1.4
Mining	2,854	12.2	7.2	4,392	20.1	13.4	2,476	13.5	15.0
Manufacturing	2,294	9.8	.5	2,706	12.4	.5	3,033	16.6	.7
Durables Goods	1,505	6.5	.7	1,822	8.3	.6	2,048	11.2	.8
Furniture, Lumber, Wood Products	1,276	5.5	3.2	1,362	6.2	3.1	1,300	7.1	4.7
Metals[3]	79	.3	.1	202	.9	.1	637	3.5	.3
Other Durables	150	.6	.4	258	1.2	.6	111	.6	.3
Nondurables Goods	789	3.4	.3	884	4.0	.4	985	5.4	.5
Food & Kindred Products	128	.5	.2	154	.7	.3	232	1.3	.5
Textile Mill Products	142	.6	.3	108	.5	.2	186	1.0	.7
Apparel & Other Fabricated Textile Products	12	.1	.1	186	.9	.5	229	1.3	.8
Printing, Publishing, Allied Products	70	.3	.2	85	.4	.3	146	.8	.5
Other Nondurables	437	1.9	.6	351	1.6	.4	192	1.0	.3
Total Extractive & Manufacturing	9,511	40.8	1.1	10,608	48.6	1.3	7,085	38.7	1.2
Service Industries[4]	7,320	31.4	.7	9,875	45.2	.8	9,644	52.7	.8
Unemployment[5]	6,483	27.8	1.9	1,353	6.2	1.3	1,574	8.6	1.7
Labor Force	23,314			21,836			18,303		
Population	73,848			72,557			61,332		
Labor Force, Proportion of Population		.316			.301			.298	

[1] The location quotient is an indicator of comparative development of an industry (as measured by employment) between the study area and the nation. As used here, it is computed by dividing the quantity (number of labor force in a given industry in the study area divided by the total labor force of the study area) by the quantity (number in labor force in the same industry in the nation divided by the labor force of the nation).

[2] Includes a small number (less than one percent of total in category) in certain forestry and fisheries categories.

[3] Includes primary metals, fabricated metals, machinery, electrical equipment, and all transportation equipment.

[4] These include essentially the noncommodity producing industries: transportation, public administration, trade, etc.

[5] In 1940, includes those employed part time or temporarily by WPA, NYA, etc.

Table 4

Bowlesburg Reservoir Report
Industrial Employment, Monongahela River Study Area
1940, 1950, 1960

Employment Category	1940			1950			1960		
	Number	Percent	L.Q.[1]	Number	Percent	L.Q.	Number	Percent	L.Q.
Agriculture[2]	19,522	2.2	.1	15,898	1.7	.1	9,913	1.0	.2
Mining	60,030	6.6	3.9	52,931	5.6	3.7	20,306	2.1	2.3
Manufacturing	251,608	27.7	1.4	317,669	33.8	1.4	320,807	33.3	1.3
Durable Goods	204,211	22.5	2.3	261,745	27.8	2.2	262,186	27.2	1.9
Furniture, Lumber, Wood Products	4,705	.5	.3	3,549	.4	.2	3,884	.4	.3
Primary Metals	181,289	20.0	3.0	150,391	16.0	8.4	138,600	14.4	8.0
Fabricated Metals[3]				75,602	8.1	1.1	90,567	9.4	1.1
Other Durables	18,217	2.0	1.4	32,203	3.4	1.8	29,135	3.0	1.5
Nondurable Goods	47,397	5.2	.5	55,924	5.9	.5	58,621	6.1	.6
Food & Kindred Products	17,195	1.9	.9	20,153	2.1	.9	23,375	2.4	.9
Textile Mill Products	1,020	.1	.1	1,348	.1	.1	578	.1	.1
Apparel & Other Fabricated Textile Products	1,855	.2	.1	2,917	.3	.2	3,591	.4	.2
Printing, Publishing, Allied Products	7,635	.8	.7	9,803	1.0	.7	13,280	1.4	.9
Chemicals & Allied Products	4,332	.5	.6	7,881	.8	.7	9,732	1.0	.8
Other Nondurables & NEC	15,360	1.6	.6	13,822	1.5	.6	8,065	.8	.3
Total Extractive & Manufacturing	331,160	36.5	1.0	386,498	41.1	1.1	351,026	36.4	1.1
Service Industries[4]	389,821	43.0	.9	494,150	52.6	.9	540,145	56.1	.9
Unemployment[5]	185,779	20.5	1.4	59,191	6.3	1.3	72,125	7.5	1.5
Labor Force	906,760			939,839			963,296		
Population	2,328,226			2,448,529			2,614,199		
Labor Force, Proportion of Population		.389			.384			.368	

1/ The location quotient is an indicator of comparative development of an industry (as measured by employment) between the study area and the nation. As used here, it is computed by dividing the quantity (number of labor force in a given industry in the study area divided by the total labor force of the study area) by the quantity (number in labor force in the same industry in the nation divided by the labor force of the nation).

2/ Includes a small number (less than one percent of total in category) in certain forestry and fisheries categories.

3/ Includes machinery, electrical equipment, and all transportation equipment.

4/ These include essentially the noncommodity producing industries: transportation, public administration, trade, etc.

5/ In 1940, includes those employed part time or temporarily by WPA, NYA, etc.

Cheat River Basin

This area is predominantly rural with relatively low population density and contains only a few small communities. The population in the economic study area remained constant at approximately 70,000 between 1910 and 1950 and then dropped to 61,300 during the last decade (see Figure II). Of the 22 municipalities in the area included in the economic study, only two are classified as urban: Elkins, which is outside the watershed, with a 1960 population of 8,307 and Kingwood with 2,530. The remaining 20 communities averaged 575 persons in 1960, a decrease from 675 in 1950. Similar trends prevail in adjacent areas. The population in the 10 counties surrounding the Cheat River Basin declined from 384,000 in 1940 to 334,000 in 1960.

The present industrial base rests primarily on the extractive industries, including agriculture, mining, and forestry. Even though changes in mining techniques have eliminated many job opportunities in this region, approximately 28 percent of the labor force in 1960 was employed in extractive industries as compared to 15 percent for the State of West Virginia and 8 percent for the nation. Manufacturing, exclusive of logging, employed approximately 10 percent of the labor force. Of the remaining 62 percent

of the labor force in the three-county area, 53 percent was employed in providing services,* utilities, and trade for the local population and 9 percent was unemployed.

Employment in all the extractive industries followed the national pattern of decline; however, the rate of decrease has been greater in the study area. Mining employment dropped from approximately 4,400 to 2,500 between 1950 and 1960. Manufacturing employment has increased uniformly since 1940.

A more favorable indication of economic activity is obtained when measured in terms of production trends. Even though there was a 55 percent drop in farm employment between 1950 and 1960, the farm output increased from $4.2 to $6.4** million during this period. Manufacturing output increased from $7.8 to $10.0** million between 1954 and 1958. Coal production has remained relatively steady at 3.7 to 4.1 million tons annually notwithstanding a drop in employment of 45 percent. Total production as measured by personal income likewise increased, but at a rate slower than the national average. Although per capita income has had a

*Services as used here refer specifically to the provision of finance, insurance, and real estate services; governmental services; welfare agency and accommodations such as medical and educational institutions, both private and public; entertainment and recreation services; and any miscellaneous non-commodity provision of services.

**Measured in constant dollars.

relatively greater increase in the study area, the per capita income as of 1960 was only 60 percent of the national average and 81 percent of the State average.

Monongahela River Study Area

During the 50-year period from 1910 to 1960 the population of the aforementioned six-county area adjacent to the Monongahela River and downstream from the Cheat River Basin advanced steadily from 1.67 to 2.61 million. This rate of increase averages about half that of the nation. The area is dominated by the Pittsburgh complex which has had a less than average rate of growth, when compared to other Standard Metropolitan Statistical Areas in its size class, for each of the last 5 decades.

Heavy manufacturing dominates the economy of the area. Major products include steel, aluminum, glass, and heavy mechanical and electrical equipment. This is a growing center for nuclear equipment, research, and development activities.

Total production has continued upward. The value of manufactured goods increased 25 percent in the past 10 years. Total personal income rose from $2.5 billion to $3.6 billion between 1949 and 1959, which is an increase of 45 percent, as compared to the national increase of 75 percent. However, the per capita income exceeds the national average by about 20 percent.

Future

The area's coal reserves (particularly in the Cheat River Basin), combined with its competitive advantage resulting from the presence of

water transportation and the fact that the area is located in the midst of the manufacturing belt of the United States, are expected to be major factors in continued industrial growth. The bulk of the future growth is expected to occur in the Monongahela River study area where present developments attest to its attractiveness as a site for industrial activities.

Prospects for economic growth in the Cheat River study area are less favorable than along the Monongahela River regardless of the planned Rowlesburg Reservoir project. The area's rugged terrain, distance from established markets, and lack of urban development are some of the more apparent reasons for a less optimistic projection for the future.

A major factor in future development is the provision of electrical power for domestic and industrial use. Between 1940 and 1960 total thermal electric energy production in the United States increased 445 percent. The proportion of this production supplied by coal energy increased 425 percent. Estimates of the increase in electric power production over the next 20 years by six authorities* range from 210 percent to over 500 percent. If the rate of increase represented by the most conservative of these projections continues until 2010, a sixteenfold increase in power production (from 849 billion kwh in 1960 to 14,000 billion kwh in 2010) would result. According to trends suggested by the Federal Power Commission and the Edison Electric Institute, the proportion of the projected power

*American Electric Power Company, Resources for the Future, Electrical World, Edison Electric Company, American Public Power Association, Federal Power Commission.

production supplied by thermal energy is expected to increase from 82 percent in 1960 to 92 percent by 2010 although the proportion supplied by coal energy is expected to decrease from about 70 percent of the thermal energy produced in 1960 to about 20 percent by 2010, being replaced primarily by nuclear energy. Thus it is estimated that approximately 2,600 billion kwh of electric energy will be supplied by coal annually by 2010. This constitutes a fivefold increase between 1960 and 2010.

On the basis that the rate of increase in electric power production in the area will approximate that in the nation, an additional 6 million kw of thermal electric power generation capacity is expected along the upper Monongahela and Cheat Rivers by 2010. Projections of electric power development in this area are regarded as conservative because, (1) only the national rate of increase was assumed, (2) of the six forecasts of national production, the one adopted was the most conservative, and (3) even though the study area has extensive coal reserves, the use of coal was assumed to be at the average national rate.

Informal information from the Federal Power Commission indicates that two large coal fired generating stations may be expected on the Monongahela River Basin in the vicinity of Point Marion in the next 10 or 20 years. It was recently reported that a 50 million dollar power project will be placed under construction in the Point Marion area in 1964 (Engineering News Record - July 25, 1963).

These factors indicate a continued growth in mining and manufacturing activity and in employment which should result in continued population growth, though at less than the anticipated national rate. Projected employment in major categories is shown in Table 5 and associated population growth in the study areas is shown in Table 6 and Figure II. Population growth in water use areas along the Monongahela and Cheat Rivers (shown in Table 6) has been estimated for purposes of estimating future water supply and water quality control needs in subsequent sections of this report.

Table 5

Rowlesburg Reservoir Report
Industrial Employment Projections
Cheat River and Monongahela River Study Areas
2010

Employment Category	Cheat		Monongahela	
	Number	Percent	Number	Percent
Agriculture	800	3.0	5,000	-
Mining	2,400	8.9	15,000	.1
Manufacturing	6,000	22.2	411,000	31.4
Durable Goods	3,700	13.7	310,000	23.7
Furniture, Lumber, Wood Products	1,800	6.7	8,000	.6
Primary Metals	1,600	5.9	130,000	10.0
Fabricated Metals 1/			138,000	10.5
Other Durables	300	1.1	34,000	2.6
Nondurable Goods	2,300	8.5	101,000	7.7
Food & Kindred Products	500	1.9	35,000	2.7
Textile Mill Products	400	1.5	3,000	.2
Apparel & Other Fabricated Textile Products	600	2.2	10,000	.8
Printing, Publishing, Allied Products	200	.7	20,000	1.5
Chemicals & Allied Products	600	2.2	20,000	1.5
Other Nondurables & NEC			13,000	1.0
Total Extractive & Manufacturing	9,200	34.0	431,000	32.9
Service Industries 2/	16,700	62.0	826,000	63.1
Unemployment	1,100	4.0	53,000	4.0
Labor Force	27,000		1,310,000	
Population	90,000		4,100,000	
Labor Force, Proportion of Population		.300		.320

1/ Includes machinery, electrical equipment, and all transportation equipment.

2/ These include essentially the noncommodity producing industries: transportation, public administration, trade, etc.

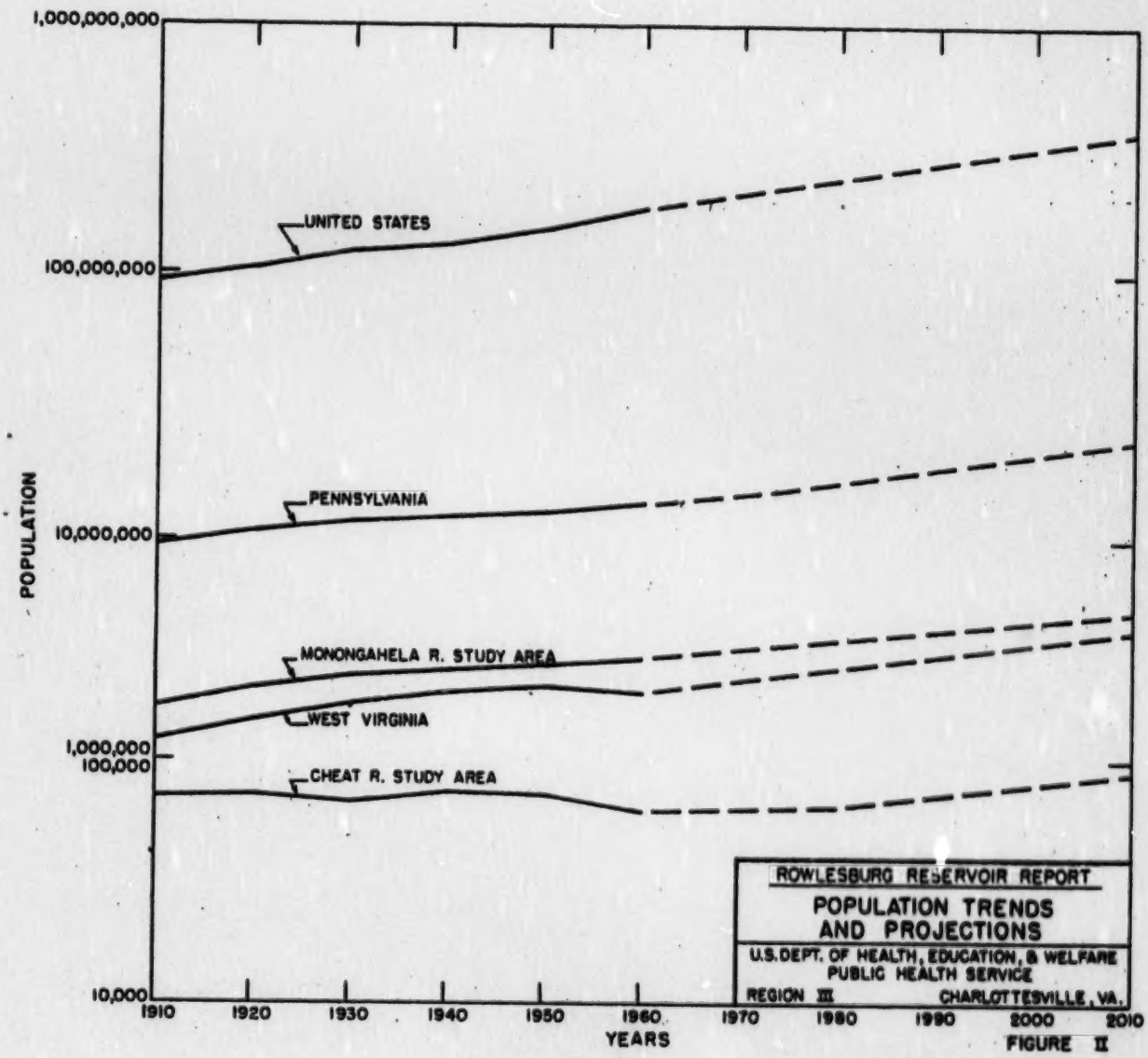

1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
POPULATION
UNITED STATES
PENNSYLVANIA
MONONGAHELA R. STUDY AREA
WEST VIRGINIA
CHEAT R. STUDY AREA
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
YEARS
ROWLESBURG RESERVOIR REPORT
POPULATION TRENDS AND PROJECTIONS
U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION III
CHARLOTTESVILLE, VA.

FIGURE II

Table 6

Projected Population
Cheat and Monongahela Rivers Study Areas

Water Use Area	Estimated Population 1960	2010
Cheat River Study Area	61,332	90,000
Monongahela River Study Area	2,614,199	4,100,000
Pittsburgh SMSA	2,405,435	3,780,000
South Pittsburgh	451,500	690,000
Green and Fayette Counties, Pa.	208,764	320,000
Monongahela	11,500	17,700
Charleroi	73,500	113,200
Brownsville	15,000	23,100
Fredericktown	10,000	15,400
Southwest Pennsylvania Water Authority	18,200	28,000
Point Marion	6,000	10,200

VI. WATER REQUIREMENTS

Water Uses and Sources of Supply

Municipal

Communities in the Cheat River Basin are small and consequently use relatively little water, as shown in Table 7.

Table 7

Municipal Water Use
Cheat River Basin

Communities	Population, 1960	Source	Average Water Used, mgd
Randolph Co., W. Va.			
Harmon	128	Spring	0.005
Preston Co., W. Va.			
Kingwood	2,530	Cheat R. Tributaries	0.103
Tunnelton	359	Wells	0.050
Rowlesburg	970	Cheat R. Tributaries	0.070
Tera Alta	1,504	Wells	0.345
Tucker Co., W. Va.			
Hambleton	275	Cheat R. Tributaries	0.006
Hendricks	407	Wells	0.065
Parsons	1,798	Cheat R. Tributaries and Wells	0.280
Davis	898	Cheat R. Tributaries	0.465
Thomas	830	Cheat R. Tributaries	0.190
Fayette Co., Pa.			
Point Marion	1,500	Cheat River	0.100
Spring Hill Twp.	4,000	Cheat River	0.520
Lake Lynn	100	Cheat River	0.010
Total	15,299		2,209

With the exception of Point Marion, water supplies are taken from wells, springs, and small impoundments on Cheat River tributaries. There are no communities between Rowlesburg and Lake Lynn securing water supplies from the main stem of the Cheat River at this time.

In contrast, the Monongahela River is extensively used as a source for municipal supplies by communities along the river between Point Marion and Pittsburgh. About 81 mgd are withdrawn for municipal purposes to serve approximately 600,000 persons (see Table 8).

Industrial

The major industrial use of Cheat River streamflow is for cooling purposes at the Albright thermal electric power plant. Other industrial water use is relatively minor and can be supplied from natural flow of the river.

There are two electric power producing developments on the Cheat River: the Lake Lynn hydroelectric power plant, and a thermal electric power plant at Albright, West Virginia. The Lake Lynn hydroelectric plant is located 4 miles upstream from the mouth of the river. A dam 125 feet high provides a reservoir approximately 13 miles long with a total storage capacity of 73,000 acre-feet. The plant has 50 megawatts of installed generating capacity and is operated for short periods to develop peak load power. At rated capacity the plant discharges up to 9,600 cubic feet per second. The Albright thermal electric plant has a capacity of 304 megawatts; about 300 cfs of stream water is used for cooling purposes at rated capacity.

Table 8

Municipal Water Use
Cheat and Monongahela Rivers

Supply	Approximate River Mile*	Source	Treatment**	Popula. Served 1961	Average Water Used gpcd	mgd
Pennsylvania						
South Pittsburgh Water Company	5	Monongahela River	F,S,D	300,000	150	45.00
Braddock	11	"	F,D	12,500	160	2.00
North Versailles Township	13	"	F,D	3,000	233	0.70
Elizabeth	23	"	F,D	36,000	125	4.50
South Pittsburgh Water Company, Shire Oaks Sta.	27	"	F,S,D	100,000	160	16.00
Monongahela	33	"	F,D	11,500	130	1.50
Charleroi	42	"	F,D	60,000	100	6.00
Belle Vernon	44	"	F,D	6,500	62	0.40
Fayette City	46	"	F,D	7,000	72	0.50
California	52	"	F,D	3,000	67	0.20
Brownsville	56	"	F,D	12,000	83	1.00
Fredericktown	65	"	F,D	10,000	60	0.60
Isabella	71	"	F,D	1,200	83	0.10
Carmichaels	76	"	F,D	2,000	100	0.20
Southwestern Penn. Water Authority	77	"	F,D	10,000	180	1.80
Masontown	79	"	F,D	5,000	100	0.50
Martin	83	"	D	200	50	0.01
Dunkard Valley Joint Municipal Auth., Greensboro	85	"	F,D	1,600	44	0.07
Alicia	86	"	F,D	200	50	0.01
Robena Mine	87	"	F,D	2,500	36	0.09
Point Marion	1.5	Cheat River	N,D	1,500	67	0.10
			Total	585,700	139	81.28

*Miles to mouth of river serving as source.
**F - Coagulation, sedimentation, filtration, and possibly neutralization.
N - Neutralization and sedimentation.
S - Soda-ash softening.
D - Chlorination.

Table 9 is a summary of industrial water use by river reaches on the Monongahela River downstream from the Cheat River confluence. An examination of this table makes obvious the relative importance of the Monongahela River as a source of industrial water supply. In excess of 6,000 mgd is being withdrawn for industrial purposes on an average annual basis.

As can be seen in Table 3, most of the employment in the Pittsburgh complex, which includes a substantial portion of the Monongahela River industrial area, is involved in the manufacture of primary metals. The steel mills in this area use large quantities of river water for cooling and process purposes.

Additional Water Needs

Municipal

Along the Cheat River below Rowlesburg there are no foreseeable water supply needs in excess of the minimum dependable streamflow. As previously indicated, the Cheat River basin is rather sparsely settled and the prospects of growth in any one area are not so great as to create a demand for water within the study period in excess of that presently available.

Table 2

Major Industrial Water Use, 1961
Monongahela River

River Mile	River Water Pumped, mgd	Use, mgd				Treatment, mgd	
		Cooling	Process	Boiler	Other	Neutralization	Softening
0-5	3,676.6	2,827.0	242.0	83.3	524.3	175.3	5.3
5-10	280.0	218.0	58.0	3.7	0.3	280.0	3.7
10-15	444.6	336.0	99.8	8.3	0.5	331.5	8.3
15-20	45.0	35.0	9.0	0.8	0.2	45.0	0.8
20-25	206.0	185.0	13.0	6.3	1.7	205.0	6.3
25-30	250.1	250.0	-	0.1	-	0.1	0.1
30-35	0.6	-	0.5	-	0.1	0.5	-
35-40	21.6	20.0	1.2	0.4	-	10.1	0.4
40-45	179.9	179.0	0.7	0.2	-	0.2	0.2
45-50	74.3	58.0	5.0	0.3	11.0	65.3	0.3
50-70	715.0	240.0	475.0	-	-	475.0	-
70-89+	171.8	-	87.2	-	84.6	1.0	-
90±			Cheat River confluence				
Total	6,065.5	4,348.0	991.4	103.4	622.7	1,589.0	25.4

Along the Monongahela River below the Cheat River confluence for some 90 river miles to Pittsburgh the projected needs for municipal water supplies are considerably greater. Presently, an estimated 81 mgd is withdrawn from the Monongahela River on an average annual basis. About 75 percent of this amount is withdrawn in the first 27 miles above the Allegheny River confluence.

Projected municipal water supply needs along the Monongahela River are shown in Table 10. Future populations are expected to increase 54 percent in the next 50 years and the per capita use of municipal water to increase from the present 139 gpcd to about 170 gpcd. On this basis the municipal water needs will reach about 155 mgd on an average annual basis by year 2010. Allowing for seasonal variations in draft, this figure will probably double on maximum days in the warm summer months to about 310 mgd (480 cfs). Owing to the distribution of use along the 90 miles to Pittsburgh, no single draft on the stream is likely to be in excess of the dependable flow, even after making generous allowances for consumptive losses, etc.

The prime problem in the Monongahela River is one of quality control. As previously indicated, even though there are adequate quantities of water available at each point of use in the stream, the reuse of water is high and the result is a general degradation in water quality.

Industrial

Present industrial water use from the Monongahela River below the Cheat River confluence averages about 1,717 mgd on an annual basis, exclusive

Table 10

Projected Municipal Water Use Along the Monongahela River

Water Use Area	River Mile*	Estimated 2010 Population	Projected 2010 Water Use in gpcd	Projected 2010 Water Needs in mgd
South Pittsburgh Area	0-30	695,320	172	119.4
Monongahela	30-40	17,700	153	2.7
Charleroi	40-50	113,200	160	18.3
Brownsville	50-60	23,100	156	3.6
Fredricktown	60-70	15,400	156	2.4
Southwestern Pennsylvania Water Authority	70-80	28,000	161	4.5
Point Marion	80-90	10,200	128	1.3
Total		902,920	169 (avg.)	152.3

*River miles on the Monongahela River measured upstream from the Ohio River confluence.

of cooling water uses and it is anticipated that it will increase to about 2,655 mgd by 2010. Table 9 shows that about 2,827 mgd of cooling water is withdrawn in the first five miles above Pittsburgh. Cooling water use is considerably in excess of the basic process, boiler, and general industrial requirements. The greatest single use is about 1,728 mgd for cooling which occurs near the Ohio River confluence. Use of this amount of water at any one site would not be possible were it not for the canalized river system making possible a relatively high reuse of water even when streamflows are low. Water use for industrial cooling also poses a quality problem because cooling use increases the stream temperature causing a reduction in the organic waste assimilative capacity.

Owing to the fact that the Monongahela River is canalized throughout, it is considered that sufficient industrial water supplies are available for present and projected future needs, except as use of the stream may be limited by quality degradation.

Stream Quality Maintenance

Sources of Wastes

Tables 11 and 12 indicate the principal sources of municipal and industrial wastes in the Cheat River Basin.

Table 11

Principal Sources of Municipal Wastes
Cheat River Basin

Source	Population 1960	Treatment 1962	Discharged to 1962
Kingwood, W.Va.	2,530	Preliminary planning under way.	Green and Indian Creeks and Morgan to Cheat River.
Rowlesburg, W.Va	970	Preliminary planning completed. Application for Federal Construction Grant received.	Cheat River.
Tunnelton, W.Va.	359	None	Pringle Run to Cheat River.
Parsons, W.Va. Outlet No. 1	1,798	Preliminary plans completed. Application for Federal Construction Grant received.	Dry Fork, Mill Race, Shavers Fork to Cheat River.
Outlet No. 2			Black Fork to Cheat River.
Hendricks, W.Va.	407	None	Dry Fork and Blackwater River
Thomas, W.Va.	830	Preliminary plans completed. Application for Federal Construction Grant received.	North Fork of Blackwater River.
Total	6,894		

Table 12

Principal Sources of Industrial Wastes
Cheat River Basin

Source	Treatment* 1957	Discharged To 1957
Rowlesburg, W. Va.		
B & O Railroad Shop		Cheat River
Albright, W. Va.		
Monongahela Power Company	Adequate	Cheat River
Parsons, W. Va.		
Dorman Mills	Adequate industrial	Tributary to Cheat
Armour Leather Company	Waste control	Tributary to Cheat

*West Virginia Division of Water Resources

The six principal communities in the Cheat River Basin comprised a total sewered population of 6,894 (see Table 11) in 1960. These communities are well dispersed throughout the basin so that no serious pollution problems prevail, except possibly in the vicinity of the various outlets during extreme low flow periods. Available information indicates that provision of adequate waste treatment will assure acceptable water quality in all cases.

The predominant industry within the valley is coal mining and processing. This is the source of the acid mine drainage problem. Acid from mine drainage has caused many serious problems and has been studied for many years. This subject is considered in the following section. Other types of industry are limited and contribute negligible waste loads to the Cheat River.

The Monongahela River is used extensively, not only as a source of water supply, but, also, to receive treated and untreated wastes from a large number of communities and industries. The population of the municipalities discharging untreated sewage to the Monongahela River in Pennsylvania is approximately 153,000. Comparable waste loads contributed by industry have not been ascertained.

In the three counties which comprise most of the Cheat River drainage basin (Preston, Randolph, and Tucker, West Virginia), coal mining is the predominant industry. Acid from coal mines is the major stream pollutant throughout the Monongahela River Basin. An acid stream is relatively void of aquatic life, thereby adversely affecting recreational and aesthetic values. Acid pollution causes corrosive damage to most structures located in or coming in contact with acid streams. It also requires more expensive treatment when these waters are used for municipal and industrial water supplies because the acid water requires greater amounts of neutralizing and softening chemicals to produce acceptable finished water supplies.

Mine acid pollution poses a serious problem now but perhaps of even greater consequence is the potential pollution load that can be expected from this source in the Cheat River Basin, unless appropriate abatement measures are employed. While the amount of acid mine drainage cannot be tied solely to the tonnage mined, the following statistics show the extent of coal mining in the basin in 1960 and indicate that because of the large coal reserves, acid mine drainage can assume ever more serious proportions if not adequately controlled. It is known that many abandoned mines continue to contribute significantly to the acid mine drainage problem.

County	Coal Removed in 1960, tons	Estimated Coal Reserves, tons
Preston	2,882,567	3,120,716,512
Randolph	1,139,382	4,129,725,310
Tucker	75,580	433,174,265
Total	4,097,529	7,683,616,087

Water Quality Objectives

The dissolved oxygen concentration in water is one index of water quality and its distribution within a river gives a measure of the imbalance between the oxygen supply and utilization within that system. Only by a study of the processes involved in this balance is it possible to assess the organic load which any stream network may receive without becoming seriously depleted of dissolved oxygen. Objectives for dissolved oxygen were set in this study in relationship to the support of a desirable aquatic environment. The maintenance of a minimum of 4 mg/l of dissolved oxygen in the Monongahela River at any point has been selected as an objective and a minimum of 5 mg/l D.O. was selected for the Cheat River below Rowlesburg. The higher Cheat River objective is necessary to preserve present and projected uses of the river as a sport fishery. With streamflow regulation the dissolved oxygen concentration will be above the objective in most years.

Observation of minimum levels of dissolved oxygen in waters favorable to a good mixed fish fauna suggests that the dissolved oxygen should not be less than 5.0 mg/l at any time. However, fish can survive at D.O. levels somewhat below this value and in the absence of toxic substances or other adverse conditions, the above value is favorable for a mixed warm water fish population and its food organisms.

The resultant change in the chemical character of streams receiving acid drainage has been established and the detrimental effects assessed. Among the more serious damages is the reduction in alkalinity, lowering of the pH, increase in the total hardness, iron, manganese, aluminum, and sulfates. This tends to render the water more expensive to treat for municipal and industrial use. It also increases corrosion damages to structures in the stream. Normal biological processes in the stream are often impaired, causing the stream to become a less desirable habitat for biological life. One objective in improving an acid stream is to seek a balance in the acidity-alkalinity concentration. Under normal conditions without adding acid contained in coal mine drainage, the Monongahela River would probably have a pH of between 6.5 and 6.8. Therefore, any decrease in acidity concentrations in the streams involved in this study, at least to the limits of the foregoing objectives, would constitute an improvement in water quality.

There are many other desirable aspects associated with improving the quality of the streams under study. Storage requirements and the beneficial effects of its provision will be assessed in view of the foregoing water quality objective and other aspects related to water quality maintenance.

Streamflow Requirements for Quality Control

The principal communities in the Cheat River valley discharging wastes to the stream below the proposed dam are Rowlesburg and Kingwood, West Virginia. Quality control flows required in the Cheat River at Rowlesburg have been determined. The flows are based on waste loads expected

from present and projected populations, plus allowances for industrial growth. It is also presumed that adequate waste treatment will be provided at each source of waste which is 85 percent BOD reduction before discharge to a stream. The oxygen demand of industrial wastes discharged after adequate treatment, or other methods of controlling wastes at the source, is estimated to be equivalent to the demand of municipal waste discharges.

On the basis of the foregoing it was found that up to 7 cfs would be required for quality control in the warm month of August by year 2010, lesser flows would be needed in other cooler months of the year.

The 7-day mean low flow of the Cheat River at Rowlesburg with a once-in-10-year recurrence frequency is 20 cfs. This is the dependability used in this study in determining needs for quality control stream discharges for organic waste assimilation purposes. On this basis there is no need of storage for water quality control in the Cheat River within the study period.

Flow requirements for waste assimilation purposes have been derived for the Monongahela River at Pittsburgh. These flow requirements are also based on projected organic waste loads that will be discharged to the stream after adequate waste treatment. High acidity concentrations in the Monongahela River have an inhibiting effect on the rate of decomposition of organic waste. The dissolved oxygen concentrations currently observed indicate a better quality of water than would actually exist under neutral or alkaline conditions. Assuming that

acid mine drainage will be adequately controlled, minimum seasonal flows shown in Table 13 will be required to assimilate waste discharges expected in 1985 and 2010.

To predict the effects of Cheat River flow regulation on acid and hardness conditions in the Monongahela River, a detailed analysis was made covering the 10-year period from 1950 through 1959. It was found, for example, that when Cheat River flows at Rowlesburg were less than 200 cfs, the average acidity concentration was 10 mg/l and the average flow was 88 cfs. The corresponding Monongahela River flow averaged 738 cfs and the acidity concentration was 55 mg/l. Assuming the Cheat River acidity would not be changed significantly by increasing the minimum flow in the Cheat River to 200 cfs, the result in the Monongahela River would be a net decrease of 6 mg/l of acidity concentration, or a drop to 49 mg/l.

This analysis was conducted for both acidity and hardness for regulated discharges of 200, 300, 500, 1,000, 1,500, and 2,000 cfs from the Cheat River and is the basis for estimates of water quality improvement benefits presented in the next section.

Plan for Supplying Future Requirements

Based on the projected needs, Rowlesburg Reservoir storage capacity is sufficient, with proper regulation, to assure future water quality control needs at least through 2010. Storage needs for years beyond 2010

Table 13

Required Streamflow Regimen for Quality Control Purposes in the Monongahela River at Pittsburgh

	1960		1985		2010	
	Minimum Streamflow cfs	Draft on Storage to Yield acre-ft.	Minimum Streamflow cfs	Draft on Storage to Yield acre-ft.	Minimum Streamflow cfs	Draft on Storage to Yield acre-ft.
January February March	1,050	-	1,875	-	2,700	-
April May June	1,560	-	2,530	-	3,500	-
July August September	1,850	36,120	2,925	170,640	4,000	364,100
October November December	1,270	-	2,185	52,500	3,100	107,400
Average Annual	1,455		2,379		3,325	
Total Annual		36,120		223,140		471,500

may be met in part by storage at the Rowlesburg site in excess of the 2010 needs, or at other sites in the Monongahela River Basin. Plans call for future additional reservoir developments in the Monongahela River Basin upstream from the Cheat River confluence. The USPHS Ohio River Basin Comprehensive Study presently under way will further investigate future water supply and quality control needs. The Ohio River Basin Comprehensive Study will be a much more all-inclusive, detailed study than that herein reported.

VII. BENEFITS OF STORAGE

Water Supply

Projected municipal water supply requirements of about 155 mgd and industrial requirements of about 2,800 mgd, exclusive of cooling water uses, are estimates of total requirements, and make no allowance for reuse along the 90-mile reach of Monongahela River above the Ohio River. This study indicates that no single water supply for either municipal or industrial purposes is expected to exceed the streamflow considered dependable for water supply purposes before 2010, the end of the 50-year study period. Therefore, no need for storage for municipal and industrial water supply purposes was found and no monetary benefit for storage for municipal and industrial water supply purposes is expressed in this report.

Thermal Electric Power Production on the Cheat River

The thermal electric power plant located at Albright, West Virginia, about 18 miles downstream from Rowlesburg, requires about 300 cfs for once-through cooling purposes to develop the installed capacity of the plant. When streamflow is less than 300 cfs, the plant can be switched to cooling by towers, a more costly method of operation, or the load may be picked up at another station, if it is more economical. Tower cooling at the Albright plant requires about 13 cfs of make-up water for continuous operation.

Approximately 50 percent of the make-up is used to replace evaporation and windage losses from the cooling towers. Existing flows are sufficient to meet present cooling water needs if towers are used whenever streamflows would otherwise be excessively heated.

Potential monetary benefits to the Albright Power Plant for assuring the 300 cfs for once through cooling purposes have been estimated in terms of the cost of replacement of existing cooling towers that would not be needed as a result of providing an assured minimum flow of 300 cfs at the end of their effective life. For estimating purposes it is assumed that 1 cfs of cooling water is required per megawatt of power produced, the average life of a cooling tower is 25 years, the cost of cooling towers is $8.00 per kilowatt of capacity, the capital cost is amortized with interest (4 percent) over the 50-year study period and annual operation and maintenance costs of cooling towers are estimated at 3 percent of the capital cost when used full time but are reduced to cover only periods of expected use. On the basis of the foregoing methodology the value of 300 cfs for cooling purposes is estimated to be $111,000 per year.

Water Quality Control

Direct Evaluation of Benefits

The value of the benefits resulting from flow regulation for quality control is the sum of the benefits for each of the quality improvements

accomplished. The benefit of each quality improvement is considered individually in the following sections and described in monetary terms where possible.

Increased Organic Waste Assimilation Capacity. Quality control flow schedules in the Cheat and Monongahela Rivers have been previously established in this study based on maintaining flows to assimilate organic waste loads that are or will be discharged to these streams and yet not reduce the stream quality below the water quality objectives. In establishing minimum flow requirements for quality control it has been assumed that secondary waste treatment or its equivalent for industrial wastes will be provided for all used water before it is discharged to the receiving stream.

Dissolved oxygen objectives were selected on the basis of present and anticipated fish and wildlife, and recreational use. While the maintenance of an acceptable dissolved oxygen level is the most general indicator of the effects of organic wastes, it is not the only parameter of importance. Concentrations of dissolved solids and nutrients, which are little affected by present waste treatment methods, are reduced by dilution flows thus reducing the potential for algal growth and associated taste and odor problems. Persistent organic materials in industrial wastes, not now removable by treatment, are also reduced in concentration. Present waste treatment methods cannot economically remove all oxidizable organic materials, nor can they remove the nutrients or refractory materials, so that provision of flow regulation improves water quality in ways not possible by treatment alone.

Meeting river water quality objectives by flow regulation in addition to the provision of adequate waste water treatment will increase the potential of the stream to support aquatic life and protect its use for water-oriented

recreational activities. Improved river water quality will also enhance the general aesthetics of the waterway and contribute to a healthful environment.

It is not possible to evaluate the monetary benefits from these improvements in water quality directly since economical waste treatment methods capable of further removal of oxidizable materials are not presently available. Only provision of added flow is presently considered capable of achieving the required quality improvements. It is on this basis that the value of the over-all quality control benefits have been approximated in terms of the alternate cost of equivalent flow regulation by a single-purpose reservoir.

Hardness Reduction. Excessive hardness is undesirable in many industrial water supplies such as laundries, carbonated beverages, metal finishing, dyeing and textile industries, food processing, pulp and paper, photography, and many others. Hard water causes excessive scale formation in water pipes, coils, tubes, and shells. Heat loss due to scale from one-fiftieth to one-ninth inch thick will be from 7 to 16 percent. In addition, costs for periodic draining of cooling systems, scale removal, and loss in production when these services are being administered must be considered.

Hardness increases the amounts of soap or detergents needed for cleaning by users of the municipal supplies. Requirements for various municipal and industrial purposes vary considerably. Hardness over 100 mg/l becomes increasingly objectionable in municipal water supplies. Industries in the Pittsburgh area indicated maximum acceptable hardness concentrations ranging from zero to 200 mg/l.* Therefore, a raw water objective of 150 mg/l has

*Allegheny River Reservoir, by Public Health Service, July 1957.

been selected as a basis for approximating the value of benefits of hardness reduction resulting from dilution with softer water from Rowlesburg Reservoir.

Water quality data on the Cheat River at Rowlesburg for the period from 1950 to 1959 indicated that the hardness varied over a range from 28 mg/l to about 45 mg/l during periods of low flow. Analysis indicates that the hardness that can be expected in Rowlesburg Reservoir releases will be about 28 mg/l on an average annual basis.

The hardness of the Monongahela River at Charleroi at various levels of streamflow has been estimated from data for the period from 1959 to 1960. The reduction in hardness resulting from several levels of regulation of the Cheat River by Rowlesburg Reservoir were estimated. Cheat River flows in the period of record analyzed were increased to 200, 300, 500, 1,000, 1,500, or 2,000 cfs and the reduction in the hardness of Monongahela River flows was estimated at each level of sustained flow. For example, Cheat River flows of less than 200 cfs were increased to 200 cfs and the reduction in hardness in the Monongahela River at Charleroi resulting from the increased Cheat River flows were determined. It was found that maintenance of a minimum flow of 200 cfs resulted in an average hardness reduction of 26 mg/l for an average of 43 days per year. The average savings in treatment costs were then estimated for each level of assured Cheat River flow.

Savings were estimated from the reduction of chemical and labor costs for treating the raw water of reduced hardness. Because the water treatment facilities are presently in existence and would still be needed at times, costs of plant construction were not included in the savings; only the savings in chemicals (lime-soda, averaging $20 per ton) plus the asso-

ciated labor costs were estimated. Savings for each of the levels of minimum flow requested are as follows:

Min. Continuous Discharge from Rowlesburg Reservoir (cfs)	Avg. No. Days Per Year Hardness Reduction Will Occur in the Monongahela River at Charleroi	Avg. Hardness Reduction (mg/l)	Average Annual Benefit (dollars)
200	43	26	7,000
300	60	30	13,000
500	94	41	24,000
1,000	153	52	50,000
1,500	170	60	64,000
2,000	185	65	76,000

While the value of these benefits are evaluated separately, they are considered to be included in the monetary benefits evaluated in terms of the single-purpose project capable of meeting quality control needs of the Cheat and Monongahela Rivers.

Acidity Reduction. As previously indicated, acid mine drainage is a severe problem in much of the Monongahela River Basin. While considerable effort has been directed to acidity control at the source, particularly for active mines, the degree to which this can be achieved cannot be determined at this time. Some of the adverse effects of high acidity can be alleviated by flow regulation by the proposed Rowlesburg Reservoir. Since the Cheat River above Rowlesburg will contain less acidity per unit of flow during periods of high runoff than during the seasons of dry weather, storage and subsequent release of this less acid

water during low flow periods will reduce the acidity concentration in the stream system below the reservoir. This will reduce the amount of chemicals needed at facilities where the acidity of the water must be neutralized before it can be used. The reduction in acidity concentration that can be expected to result from flow regulation by Rowlesburg Reservoir has been estimated in the same manner that was previously presented for hardness reduction.

Available water quality data collected by the PHS and other Federal agencies indicate that the acidity concentration of the Cheat River waters at Rowlesburg may be expected to range from as low as 2 mg/l during high flow periods (up to 3,000 cfs), to as high as 15 mg/l during low flow periods. Analysis indicates that the average annual acidity concentration in the post-impoundment periods will be about 10 mg/l. Effective progress in future acid mine drainage abatement programs would tend toward even lower figures.

Acidity concentrations in the Monongahela River at Charleroi are generally much greater than in the Cheat River at Rowlesburg. When the Cheat River is discharging less than 2,000 cfs at Rowlesburg, average acidity at Charleroi is 33 mg/l; when less than 1,000 cfs, 39 mg/l; and when less than 200 cfs, 55 mg/l. If Cheat River flows were sustained at 2,000 cfs the average acidity concentration in the Monongahela River would be decreased 17 mg/l over the period of 185 days when Rowlesburg Reservoir would assure increased flow. An estimate of the savings in the cost of chemicals (lime) that will be realized by plants neutralizing water supplies withdrawn from the Monongahela River was developed for various regulated levels of Cheat River discharge:

Min. Continuous Discharge from Rowlesburg Reservoir cfs	Avg. No. Days Per Year Acidity Reduction Will Occur in the Monongahela River at Charleroi	Avg. Acidity Reduction mg/l	Average Annual Benefit dollars
200	43	6	17,000
300	60	7	38,000
500	94	8	87,000
1,000	153	12	219,000
1,500	170	15	330,000
2,000	185	17	275,000

While the value of these benefits are evaluated separately, these monetary benefits are considered to be included in the benefit evaluated in terms of the single-purpose reservoir to meet flow regulation needs on the Cheat and Monongahela Rivers.

Corrosion. Damages caused by the corrosive action of acid waters in the Monongahela River are of considerable concern both in the stream and to all users of raw river water. Most of the acidity in the upper Ohio River is attributable to acid mine drainage originating in the Monongahela River Basin. Acid corrosion results in damages to floating navigation plants and to submerged portions of structures such as locks and dams, harbor facilities, and bridges. The U. S. Public Health Service conducted a re-evalution of corrosion damages to navigation interests in 1954 in connection with the report on the Stonewall Jackson Reservoir on West Fork River in the Monongahela River. This re-examination was essentially an updating of results reported in 1940 in "Report of the United States Public Health Service on Ohio River Pollution Control" (House Document No. 266, 78th Congress). The estimates of these damages have again been updated by the Corps of Engineers as follows:

Boats	$354,000
Barges	483,000
Locks & Dams	40,000
	$877,000 (annually)

Estimates of the reduction in the above tangible corrosion monetary damages which will be realized by flow regulation from Rowlesburg Reservoir are as follows:

Min. Continucus Discharge from Rowlesburg Reservoir cfs	Reduction in Damages dollars
200	12,000
300	22,000
500	37,000
1,000	99,000
1,500	128,000
2,000	164,000

In addition to the above reduction in damages to navigation facilities due to reductions in acidity concentrations there will be reductions in damages to all facilities that are adversely affected by contact with acid waters. It is not possible to estimate these damages at this time.

Decreased Water Temperature. Table 9 shows that in 1961, 4,348 mgd of Monongahela River water was used for industrial purposes. More than 70 percent of the industrial water used along the Monongahela River was for cooling purposes, about 65 percent of which was concentrated in the first 5 miles of the Monongahela River above Pittsburgh.

National steel production in 1961 was about 98 million tons. Estimates of future production indicate this quantity will increase to about

175 million tons by 2010. Currently, 15 to 20 percent of the nation's steel production facilities are located along the Monongahela River. Even though the percentage of the nation's steel production facilities that will be located along the Monongahela River is not expected to increase in the future, a net increase in steel output is expected in the area.

In view of the above steel production figures and the fact that as much as 64,000 gallons of water may be required in the production of a ton of highly finished steel by methods currently employed in this area, the future need for relatively large quantities of cooling water in the Monongahela River is obvious.

Attendant to the production of steel and other allied products is the need for large quantities of electric power. Thermal electric generating stations use about 240,000 gallons of cooling water for each ton of coal consumed in power production. This power is vital to the economy of the area.

The result of these various cooling water uses is a general degradation of water quality caused by the resulting higher river water temperatures. In the 5 miles of stream above the Ohio River the water temperature varies between 2 and 10°F. above normal through the year. This increased water temperature results in greater streamflow requirements for quality control purposes when flow needs are based on dissolved oxygen and the assimilation of organic wastes.

Lower water temperatures are also beneficial to industry in that the efficiency of heat transfer in the cooling units is improved, thereby reducing the amount of water that need be pumped. The reduction in fuel consumption resulting from increased plant efficiencies can result in very substantial savings.

Flow regulation by Rowlesburg Reservoir will result in a measurable reduction in the effect of waste heat on the temperature of the Cheat and Monongahela Rivers by maintaining greater flow volumes to assimilate and subsequently dissipate the heat.

For estimating purposes the temperature of the increased flow resulting from flow regulation was assumed to be equal to the mean monthly air temperature. The temperature of natural or existing Monongahela discharges was assumed to be equal to the observed average water temperature for each month. The temperature reduction was determined as the difference between the existing Monongahela River water temperature and the weighted mean temperature of Monongahela and regulated Cheat River flows. Monetary benefits were based on the average number of days per year that these reductions might be expected and a value of $0.05 per day per degree Fahrenheit temperature reduction per million gallons of cooling water employed. The value of a unit of temperature reduction varies considerably among industries and is related to the products involved. The $0.05 figure was found to be fairly representative of values for cooling water used in similar evaluations of cooling water benefits on the Mahoning River ($0.02 to $0.07) and values reported by electric power industries in the Monongahela River Basin ($0.05). The resulting value of the benefits to cooling water users are shown as follows:

Min. Continuous Discharge from Rowlesburg Reservoir cfs	Average Annual Benefit dollars
200	15,000
300	21,000
500	44,000
1,000	86,000
1,500	153,000
2,000	170,000

Alternative Cost Evaluation of Benefits

The projected needs for storage for flow regulation to maintain surface water quality were developed in preceding sections. When possible, the value of the benefit of providing storage to meet quality control flow schedules was determined from assessed tangible benefits that will be realized as a result of streamflow regulation. Where no appropriate means can be found for direct evaluation, the estimated cost of achieving equivalent improvements in water quality by the most likely alternative means is used as an approximation of the over-all benefit. The most reasonable alternate to the multiple-purpose reservoir is a single-purpose reservoir developed for the purpose of water quality control. This alternate single-purpose reservoir would be constructed at the least costly location capable of providing the same control of water quality as the proposed multiple-purpose impoundment.

Provision of storage for flow regulation planned for Rowlesburg Reservoir can improve the quality of the Cheat River, the reach of the

Monongahela River from Point Marion to its mouth and the upper reaches of the Ohio River. The adverse effects of organic wastes remaining even after adequate treatment, as measured by the effect on dissolved oxygen, can be reduced to acceptable levels. The concentrations of soluble nutrients resulting from domestic and other wastes, which are not significantly reduced by available treatment methods, can be reduced by dilution. While flow regulation needs in this study are based on the flow schedules developed for organic waste assimilation, provision of these flows will result in substantial improvement in other measures of stream quality which are important to the many legitimate uses of the rivers involved. The hardness of existing low flows can be reduced, resulting in savings in costs at municipal and industrial water treatment plants. The acidity of existing low flows can be reduced, resulting in savings in costs of neutralization at treatment plants and in costs of replacement of facilities whose lives are extended by the reduction of corrosion. The effect of thermal pollution can be reduced because of the greater volume of water available thus reducing the temperature at subsequent points of cooling use and reducing the effect on organic waste assimilative capacity.

Provision of storage in the Rowlesburg Project to provide a draft on storage of 471,500 acre-feet,* estimated to be necessary to meet streamflow requirements in the Monongahela River at Pittsburgh in 9 years out of 10 in 2010, will provide benefits having an estimated average annual value of $2,648,000. A single-purpose project at the Rowlesburg site is

*This is the quantity needed at Pittsburgh and does not consider storage and transmission losses.

estimated to cost $65 million and appears to be the most reasonable alternative to the Rowlesburg multiple-purpose project if developed to meet 2010 needs. The above monetary benefits are based on spreading the capital cost over a 50-year amortization period with interest at 3 percent, plus $121,000 per year for operation, maintenance, and contingencies. While the benefits discussed apply primarily to the Cheat and Monongahela Rivers, widespread benefits to water quality will also be realized along the entire length of the Ohio River.

If the storage provided in Rowlesburg Reservoir is not sufficient to meet the quality control flow schedules or if needs for other purposes prevent meeting quality control objectives at certain times, the value of the benefits must be appropriately reduced. The need for storage for water quality control may be expected to continue to increase beyond 2010. These needs may be met by additional storage in Rowlesburg Reservoir or at other sites in the Monongahela River Basin.

It is recommended that multilevel outlets be included in the proposed Rowlesburg Reservoir Project. This would provided flexibility in reservoir operation to facilitate selecting those storage levels to supply the best downstream water quality possible and to assure that water quality objectives will be met by the project. A minimum requirement based on present knowledge of reservoir water quality would call for at least three outlets. Although variable-level outlets would be more desirable, provision of a low-level, median-level, and near-surface level (corresponding to average reservoir operation levels) should be sufficient. Keeping in mind pertinent parameters of water quality, such as pH, temperature, and dissolved oxygen, installation

of recording instruments to indicate water quality at the several levels would also be a very beneficial provision.

Off-Peak Releases from Rowlesburg Reservoir and Lake Lynn

Minimum or off-peak releases from Rowlesburg Reservoir should be established at a level that diurnal and weekly variations in water quality will not be excessive. It is important to maintain streamflow in the Cheat River in the reach between Rowlesburg and Lake Lynn sufficient to dilute acid loads from several small tributaries which are intermittently acid through the seasons. This is of special significance in view of a need to preserve and protect existing and future aquatic life in this section of the river for recreational purposes. This reach presently has a desirable fishery which should be maintained although acid conditions have inhibited the development of aquatic life to its full potential. A minimum flow of 300 cfs is considered necessary for this purposes.

As previously noted, there is also a need for a minimum flow of 300 cfs in the Cheat River at Albright for cooling water supply purposes. The 300 cfs minimum flow would dissipate the resulting heat loads and safeguard against possible thermal pollution problems that might occur in the Cheat River between Rowlesburg and Lake Lynn.

Higher flows would be desirable to still further reduce possible adverse quality effects. The State of West Virginia has indicated an interest in the maintenance of a streamflow as much as 600 cfs below Rowlesburg in the Cheat River.

The cost of a single-purpose reservoir to reregulate peaking power flows below Rowlesburg Reservoir to maintain a minimum of 300 cfs during

off-peak periods is estimated at $1.5 million. On this basis the value of the benefits from maintaining a minimum flow of 300 cfs would be $65,000 per year which is the capital cost of the reregulation dam amortized over 50 years at 3 percent interest and $7,000 a year for operation and maintenance. The total project benefit of $2,648,000 per year would be reduced by $65,000 if the 300 cfs minimum flow is not continuously maintained in the Cheat River below Rowlesburg, since provision of 300 cfs minimum flow was assumed in the overall benefit evaluation.

There is also a need for a minimum continuous flow of high quality Cheat River water in the Monongahela River. Cheat River discharges are affected by peaking power production at the existing Lake Lynn project and will vary over a wide range on a daily and weekly basis. This variation could result in diurnal fluctuations in quality in the Monongahela River downstream from the mouth of the Cheat River until these slugs of Cheat River water are dispersed by longitudinal mixing.

The effects of peaking power flows from the Cheat River on the water quality in the Monongahela River cannot be readily estimated. A detailed field investigation of considerable magnitude would be required to determine the length of river over which fluctuating water quality would seriously affect water use. When flow in the Monongahela River is low, the quality may be expected to be poor so that dilution with better quality Cheat River flows is desirable to minimize fluctuations in water quality in the Monongahela River. Off-peak flow releases of at least 300 cfs from Lake Lynn should be maintained during periods when the Monongahela River at the Cheat River confluence falls below 1,000 cfs.

For Monongahela River flows above 1,000 cfs quality can be expected to be somewhat improved and the minimum flow provided will have relatively less affect on quality than at lower flows. The Monongahela River discharge at this point can be expected to be less than 1,000 cfs an average of 43 days per year. If minimum flow releases are not provided, previously estimated benefits for reductions in acidity and hardness would be reduced in the upper reaches of the Monongahela. Considering longitudinal mixing, it is assumed that the adverse quality effects would not persist beyond Charleroi. On this basis the following reductions in the value of the benefits would be applied if the minimum flow of 300 cfs were not maintained below Lake Lynn:

Min. Continuous Discharge from Rowlesburg Reservoir cfs	Annual Reduction in Benefits dollars	
	Hardness	Acidity
200	1,190	2,890
300	2,890	7,010
500	4,080	14,790
1,000	8,050	37,230
1,500	12,240	56,100
2,000	12,920	63,750

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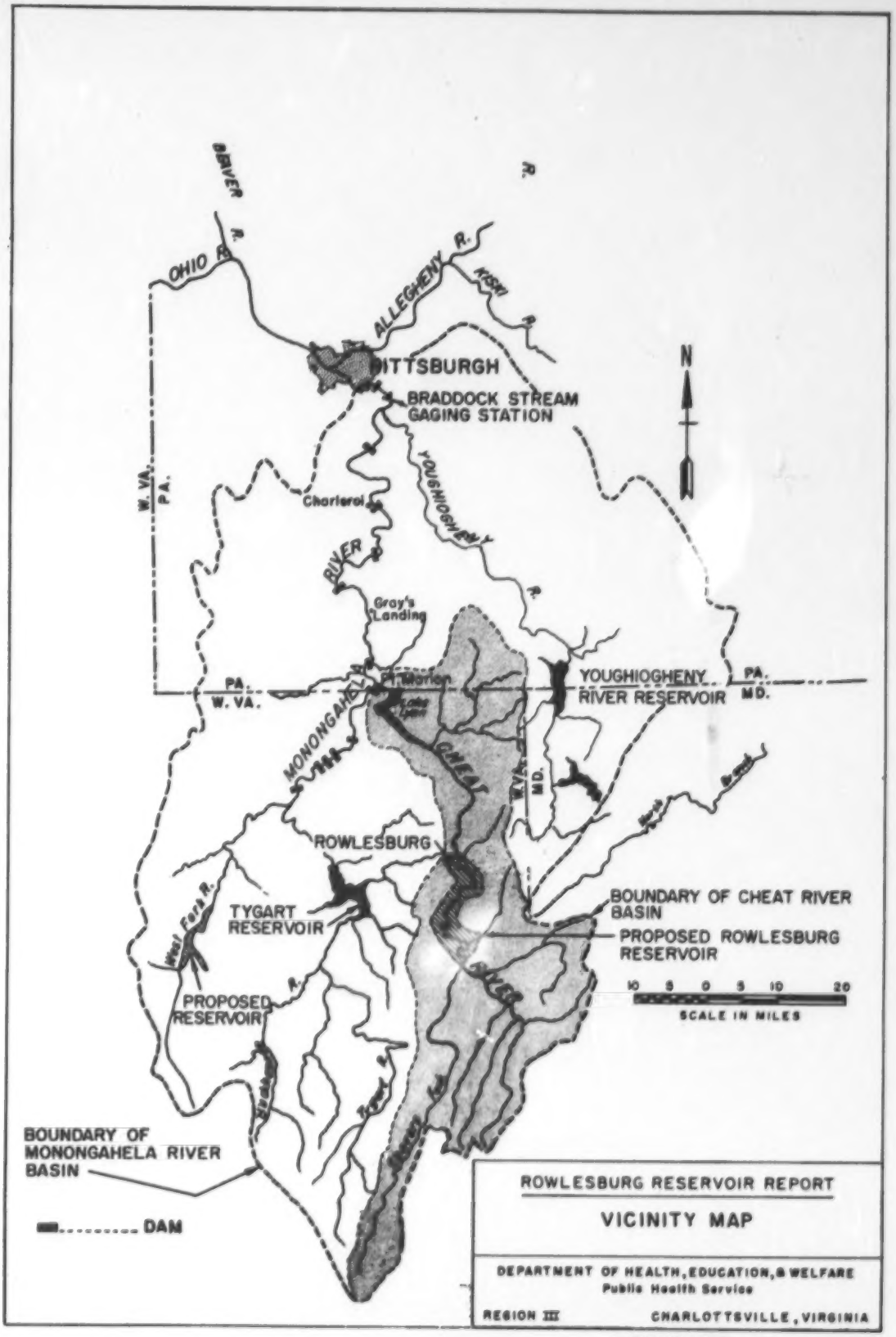
OHIO R.
ALLEGHENY R.
KISKI R.
ITTSBURGH
BRADDOCK STREAM GAGING STATION
N
W. VA.
PA.
Charleroi
YOUGHIOGHENY RIVER
Gray's Landing
Marion
PA.
W. VA.
YOUGHIOGHENY RIVER RESERVOIR
PA.
MD.
MONONGAHELA
CHEAT
W.VA.
MD.
ROWLESBURG
TYGART RESERVOIR
West Fork R.
PROPOSED RESERVOIR
BOUNDARY OF CHEAT RIVER BASIN
PROPOSED ROWLESBURG RESERVOIR
10 5 0 5 10 20
SCALE IN MILES
BOUNDARY OF MONONGAHELA RIVER BASIN
DAM
ROWLESBURG RESERVOIR REPORT
VICINITY MAP
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION III
CHARLOTTSVILLE, VIRGINIA

FIGURE III